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(54) APPARATUS FOR MEASURING O_2 CONCENTRATIONS IN GASES

(71) We, VEB KOMBINAT MESS-UND REGELUNGSTECHNIK DESSAU, a corporation organised under the laws of Eastern Germany, of 43, Altenerstrasse, 45 Dessau, Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a measuring apparatus for accurately measuring O_2 concentrations in gases by means of physical measuring detectors.

With physical analysis of substances, the measurement effects often appear masked by disturbing effects.

In connection with thermomagnetic O_2-analysis, some properties of the residual gas admixed with the oxygen are for example also included. The exclusion of the disturbing effect of the carrier gas is a very important problem in the development of systems of physical analysis of O_2.

Especially for the analysis of oxygen, apparatus are known which use measuring detectors, with which the magnetic susceptibility is directly measured, isolated from disturbing influences. These measuring detectors have not proved satisfactory when working under rough conditions. They are sensitive to dust particles, show an unfavourable behaviour as a function of time and are relatively costly to manufacture.

It is also known that disturbing of carrier gas effects may be excluded by incorporating special thermal auxiliary measuring detectors in the same measuring unit and measuring gas stream with the thermomagnetic O_2 measuring detector and in this way a reduction of the interfering influence is obtained for small changes in carrier gas and changes in O_2 concentration.

The connection in opposition of two voltages of different measuring detectors does not give any comprehensive compensation of the disturbing effects and involves an individual adaptation of the measuring installation to the actual case of operation. The relatively troublesome method is not satisfactory in practice.

In the industrial measuring art, the thermomagnetic measurement of O_2 by the annular chamber principle has proved satisfactory. The dependence occurring therewith of the output voltage on the so-called carrier gas factor $\frac{SH \cdot d}{kv}$ can however lead to measurement errors between 60% too small a measurement and 500% too large a measurement. In the formula:

$$\left.\begin{array}{l} SH \text{ represents specific heat} \\ d = \text{density} \\ kv = \text{kinetic viscosity} \end{array}\right\} \text{of the gas mixture to be tested}$$

In order nevertheless to obtain accurate analysis values, only strictly limited fluctuations in the carrier gas composition are permitted in practice.

In the textbook entitled "Messen und Regeln in der Chemischen Technik" ("Measuring and Regulating Processes in Chemical Engineering"), published by Springer (Berlin/Gottingen/Heidelberg), 1964, pp. 532—534, the function of thermomagnetic O_2 analysers is described, which have no additional interfering convection effect.

Additional interfering convection forms a supplementary influence and has to be eliminated by a counter-connection with a comparative cell. In the apparatus according to the present invention additional interference from convection does not occur.

In all thermo-magnetic measuring processes, however, a further interference occurs by the product of the O_2-governed part of the signal and the carrier gas factor. If the characteristic data K of a measuring detector are regarded as constant, then the equation (on simplified lines) is as follows;

$$\text{Measuring signal } e = K.p\ O_2 . \frac{SH.d}{kv}$$

Where p O_2=real O_2 concentration in vol. %.

The main objec of the present invention is thus to eliminate the faults occurring by multiplication of factors, the so-called carrier-gas effect. The thermomagnetic measuring detectors adopted will be of the type not having any supplementary additive convection interference effect.

According to the present invention there is provided a measuring apparatus for the accurate detection of O_2 concentration in a gas, comprising a thermo-magnetic apparatus having two measuring chambers, a first detector in the first chamber for forming a signal which is proportional to the product of the O_2 concentration and the interference influence of a carrier gas, the O_2 concentration of which is to be detected, and a second detector in the second chamber for forming a signal proportional to the interference influence, the measuring apparatus further comprising means for deriving from the signals from said detectors a resultant equivalent to the signal of said first detector divided by the signal of the second detector, and wherein the ends of a U-shaped tubular passage of said second chamber are connected to a differential pressure regulator which is connected to an absolute pressure regulator.

In the simplest form, the evaluation of the signals is effected by a recording of two instantaneous values. The obtaining of the analysis value without dependence on the carrier gas factor is effected by division of the two actual instantaneous values.

It is also possible to effect the automatic correction, utilising the two measurement signals, in an analogue computer.

If a suitable digital computing arrangement is provided for the detection of the complex numerical measurement data, then it is possible for the two measurement signals to be converted into a digital form and for a digital quotient formation to be carried out.

A constructional embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing which shows diagrammatically an apparatus according to the invention.

The measuring apparatus comprises two similar detectors or sensors 1, 11, a differential pressure regulator 18, an absolute-pressure regulator 22 for the measuring gas, gas-connection conduits, a computer shown schematically, having an indicator, and with electric voltage-sources.

The sensor 1, with channel borings 2, two measuring tubes 3, attached to the interior of the channel borings with adhesive in a gastight manner and having heating coils 4, 5, 6 and 7, measuring-gas sample conduit 8 situated transversally to the channel borings, a double pair of pole pieces 9, with a magnet system (not shown) and with ducts 10, is used as the O_2 measuring sensor.

The sensor 11 differs from the sensor 1 by the omission of the magnetic system with the pole pieces. In addition, the gas conduits ars differently arranged and connected.

Both sensors, the differential pressure regulator 18 and the absolute-pressure regulator 22 for the measuring gas are interconnected by gas conduits 12, 13, 14 and 15. Heating resistances in both sensors are in each case connected to form Wheatstone bridges.

The gas to be examined passes through the sensor 1 and the sensor 11. The laminar choke 20 serves to limit the quantity flowing through the sensor 1. The thermo-magnetic wind produces, in the two tubes 3 of the measuring sensor 1, a differential pressure which is proportional to the O_2 content. This pressure is of the order of magnitude of 10^{-2} mm (wat.col.) and cannot be measured direct except at the cost of considerable apparatus and labour. The flow which it produces in the tubes is therefore measured. To carry out all measurements at the same absolute pressure the absolute pressure regulator 22 is connected into the measuring gas feed conduit. In this process the composition of the carrier gas influences the sensitivity of the measuring apparatus. In order to measure this effect, the differential pressure in the sensor 11 is kept constant for all gases.

The output signal is then proportional to the change caused in the sensitivity of the measuring sensor by the carrier gas. The pressure in the sensor 11 is likewise in the order of magnitude of 10^{-2} mm (wat.col.). By the aid of the laminar chokes 19 and 21, the output pressure of the differential pressure regulator 18, which contains the two tubes 16 and 17, is reduced from about 50 mm (wat.col.) to the extent required to ensure that the required differential pressure prevails.

The dual arrangement of the measuring tubes in the two measuring chambers ensures that no thermal convection causing interference can occur, because the thermal buoyancy forces in the two tubes are in each case equal and take the opposite direction to each other.

The apparatus includes an electrically heated thermostatically controlled chamber (not shown) which surrounds both measuring sensors.

The inaccuracy of the measurement information which is possible with the physical oxygen measuring installation as described falls from formerly −60% to +500%, to within a few percent of the actual value.

WHAT WE CLAIM IS:—

1. A measuring apparatus for the accurate detection of O_2 concentration in a gas, comprising a thermo-magnetic apparatus having two measuring chambers, a first detector in the first chamber for forming a signal which is proportional to the product of the O_2 concentration and the interference influence of a carrier gas, the O_2 concentration of which is to be detected, and a second detector in the second chamber for forming a signal proportional to the interference influence, the measuring apparatus further comprising means for deriving from the signals from said detectors a resultant equivalent to the signal of said first detector divided by the signal of the second detector, and wherein the ends of a U-shaped tubular passage of said second chamber are connected to a differential pressure regulator which is connected to an absolute pressure regulator.

2. A measuring apparatus as claimed in claim 1 wherein each chamber comprises a bored body portion and two parallel tubes hermetically mounted in said body portion, one end of each tube communicating with a conduit for the gas to be measured and each tube being surrounded by a heating coil having a central tap, a pole piece being provided at right angles to one end of each coil in the first chamber and the said one ends of the tubes of the second chamber being connected to said conduit by respective laminar chokes.

3. A measuring apparatus as claimed in claim 1 or 2 wherein both measuring chambers are mounted within an electrically heated thermostatically controlled chamber.

4. A measuring apparatus substantially as herein described with reference to and as illustrated by the accompanying drawing.

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1215303 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*